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ASSESSMENT OF COMPUTERIZED TOMOGRAPHY DEVICES IN MINAS GERAIS

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ABSTRACT

Computed Tomography (CT) is the diagnostic imaging method most commonly performed today. It is a device that is undergoing a technological evolution and their quality control is sorely needed. The image quality evaluation process allow a better diagnosis and control of the patient dose received during image acquisition. The CT doses are higher than other X-ray examination techniques, like a conventional X-ray. Performance evaluation of computed tomography in Minas Gerais is not significant. Therefore, this work aims to analyze 20 CT equipment in Minas Gerais, with parameters according to the national regulatory agency (ANVISA –Agência Nacional de Vigilância Sanitária) in twelve quality control tests.

Sixty five percent (65%) of CT equipment evaluated showed excellent results and were not disapproved in any of the tests performed and 30% had failed in only one of the twelve tests performed.
The worst result was found in the CT scanners in the test that evaluates the low contrast resolution, where 20% of CT showed non-compliance, followed by the test that evaluates the x-rays collimation beam, where 15% had failed.

The tests allowed us to observe that the twenty computerized tomography equipment achieved a great pass rate. Considering that the evaluated CTs performed the quality control tests for the first time, it is concluded that the equipments used in clinics and hospitals are of good quality image and low radiation doses.

1. INTRODUCTION

The CT has revolutionized radiological studies intending to provide visualization of anatomical structures in the axial, sagittal and coronal planes. This complementary method of imaging can distinguish differences in density of about 0.5% between tissues, whereas in conventional radiology this threshold is approximately 5% [1-3].

The CT scan is very important in the diagnosis and monitoring of pathological changes, being among the most frequently performed radiological examinations today. According to the National Registry of Health on Brazilian Health Department, there are 284 CT scanners in Minas Gerais [4].

Due to the expansion of the use of ionizing radiation in medicine and the risks inherent in its use, it is necessary to establish a radiation protection in diagnostic radiology equipment. To ensure the quality of radiology services provided to the population, control tests should be performed regularly to evaluate the performance of equipment, ensuring a better quality image. Thus, there will be a possible reduction of misdiagnoses, repetition of tests, patient dose and equipment waste [5-6].

When equipments are not working properly, they can result in a poor quality exam and may present noise, low contrast, scattered radiation, artifact or low sharpness. Aiming to reduce these risks, the quality control tests were created in radiology diagnostic.

In this work the following tests were performed: the assessment of collimation system, alignment of gantry lasers with the center of imaging plane, table longitudinal motion, radiation profile width, gantry tilt accuracy, random uncertainty in pixel value (noise), field uniformity, accuracy of the CT number, spatial resolution (High Contrast Resolution), contrast resolution (Low Contrast Resolution) and Multiple Scan Average Dose (MSAD).

2. MATERIALS

To perform the experimental study, 20 CT scans of MG were analyzed. The sample consisted of different manufacturers and models of CT scanners, as shown in Table 1.

TABLE 1: Characteristics of CT scanners evaluated.

TC	Manufacturer/Model	City
1	Philips / Brilliance	Belo Horizonte
2	GE / CT Sytec Synergy	Belo Horizonte
3	Picker / PQ 5000	Juiz de Fora
4	Siemens / Somatom Spirit	Ouro Branco
5	GE / Hi Speed	Mariana
6	Philips / Brilliance	Belo Horizonte
7	Philips / Brilliance	Belo Horizonte
8	GE / Hi Speed	Contagem
9	GE / Hi Speed FX/i	Varginha
10	Toshiba / Asteion	Belo Horizonte
11	Toshiba / Asteion	Campo Belo
12	GE / CT/e	Alfenas
13	Toshiba / Asteion	Conselheiro Lafaiete
14	Philips / Brilliance	Poços de Caldas
15	Philips / Brilliance	Poços de Caldas
16	Siemens / Somatom Sensation	Belo Horizonte
17	Siemens / Somatom Spirit	Curvelo
18	GE / BrightSpeed	Divinópolis
19	GE / HiSpeed	Belo Horizonte
20	Siemens / Somatom Espirit +	Belo Horizonte

For data analysis we used the following instruments: a phantom, manufactured by Phantom Laboratory, Catphan model 500, serial number 500296 [7], an ionization chamber for beam computed tomography, manufactured by Radcal Corporation, 10x6-3 CT model, serial number 05-0395; data collection for the tests in scanners, 360 protractor, masking tape, tape measure, radiographic film, opaque envelope and needle.

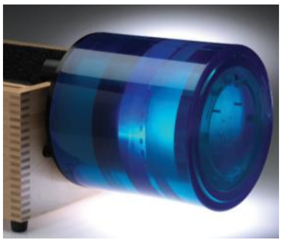

Figure 1 – Catphan CT phantom.

Figure 2 – CT ionization chamber.

3. METHODS

The CT scans were evaluated in eleven quality control tests in order to verify the adequacy.

3.1. Assessment of collimation system, alignment of gantry lasers with the center of imaging plane, table longitudinal motion and radiation profile width

Four parameters were evaluated in this section:

- The collimation system and the coincidence of internal and external lasers with the radiation beam. The tolerance limit is ≤ 2 mm.
- The gantry lasers are parallel and orthogonal with the imaging plane over the full length of laser projection. The tolerance limit is ≤ 5 mm.
- The table longitudinal motion, to verify it according to digital indicators accuracy and reproducibility. The tolerance limit is ± 2 mm.
- The radiation profile width, to verify that it meets manufacturer specification. The tolerance limit is ± 1 mm.

3.2 Gantry tilt accuracy

This test evaluates the accuracy of gantry tilt indicators. The measured angle and nominal angle deviation should be ± 3°.

3.3 Random uncertainty in pixel value (noise), field uniformity and accuracy of the CT number

The random component of image non uniformity is called noise. The standard deviation of pixel values in a region of interest (ROI) within a uniform phantom is an indication of image noise. The noise can be expressed in terms of standard deviation of the CT numbers in Hounsfield Units (HU) or as a percent of the linear attenuation coefficient of water [8, 9]. The tolerance limit for this test is ± 10% or 0,2 HU, whatever is larger.

Scanning a uniform phantom and sampling mean HU values for ROIs of fixed areas throughout the phantom can quantify the presence of systematic variations. CT images should be free of artifacts from the system, and an image of a uniform phantom should have uniform appearance without streaking and artifacts. The water scan which is used to verify CT field uniformity should have a tolerance of ± 5 HU.

The procedure to evaluate the accuracy of the CT number is performed with a density phantom (Catphan 500) and is similar to the test for evaluation of field uniformity. After scanning the uniform section of the phantom, the ROI tool is used to measure the mean CT number for water. This value should be within an acceptable tolerance (usually 0 HU ±5).

3.4 Spatial Resolution (High Contrast Resolution)

It characterizes the imaging system's ability to distinguish between two very small objects placed closely together. Spatial resolution measurements are performed with objects which have a high contrast (contrast difference of 12% or greater) from uniform background. The CT systems must be able to distinguish objects up to 5 mm to 0.5% contrast.

3.5 Contrast Resolution (Low Contrast Resolution)

Contrast resolution can be defined as the CT-scanner's ability to distinguish relatively large objects which differ only slightly in density from background. Low contrast resolution was evaluated with a Catphan 500 phantom that contains low contrast objects of varying sizes. The CT systems must be able to resolve objects up to 5 mm to 0.5% contrast.

3.6 Multiple Scan Average Dose (MSAD)

When performing a volumetric scan dose, profiles from individual scans are superimposed and summed to create a multiple scan profile. The aim of this test is to determine the representative absorbed doses of typical adults protocols. The MSAD value limits for head protocol is 50 mGy, for lumbar spine protocols is 35 mGy and abdomen protocol is 25 mGy.

4. RESULTS

4.1. Assessment of collimation system, alignment of gantry lasers with the center of imaging plane, table longitudinal motion and radiation profile width

According to results, Figure 3 shows that all the CT are suitable for use in medical routine. The alignment offset presented by 19 of the 20 CT did not cause a harmful dose distribution, which could decrease the image quality, generating possible artifacts and contributing to a false diagnosis. Only CT-16 showed poor outcome of these evaluations. This suggests a high quality of the evaluated equipments.

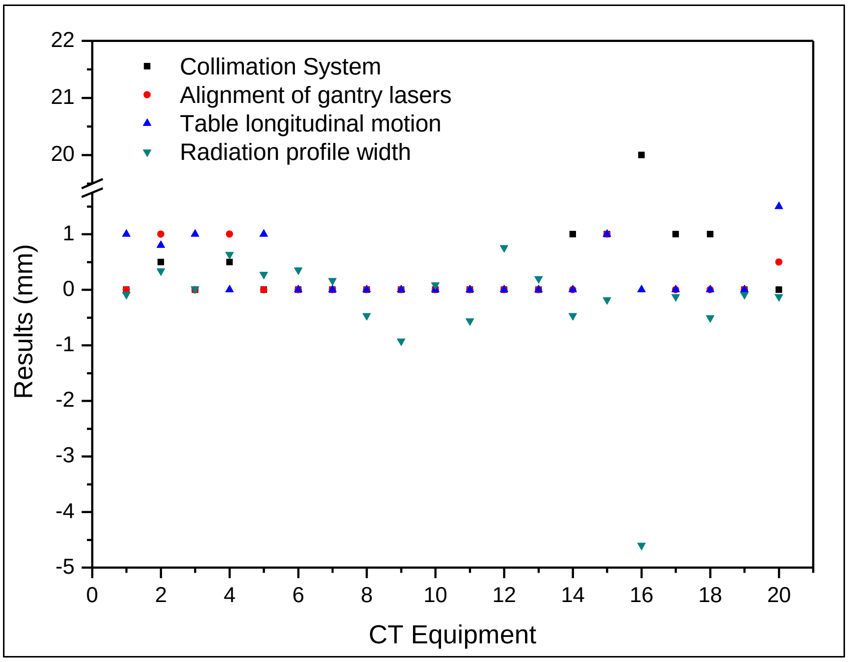

Figure 3 – Assessment of collimation system, alignment of gantry lasers with the center of imaging plane, table longitudinal motion and radiation profile width.

4.2 Gantry tilt accuracy

According to Figure 4 all CT evaluated in this test were approved. It suggests that the control panel indication of the equipment corresponds to the real tilt. This ensures the implementation of the protocols with greater diagnostic confiability.

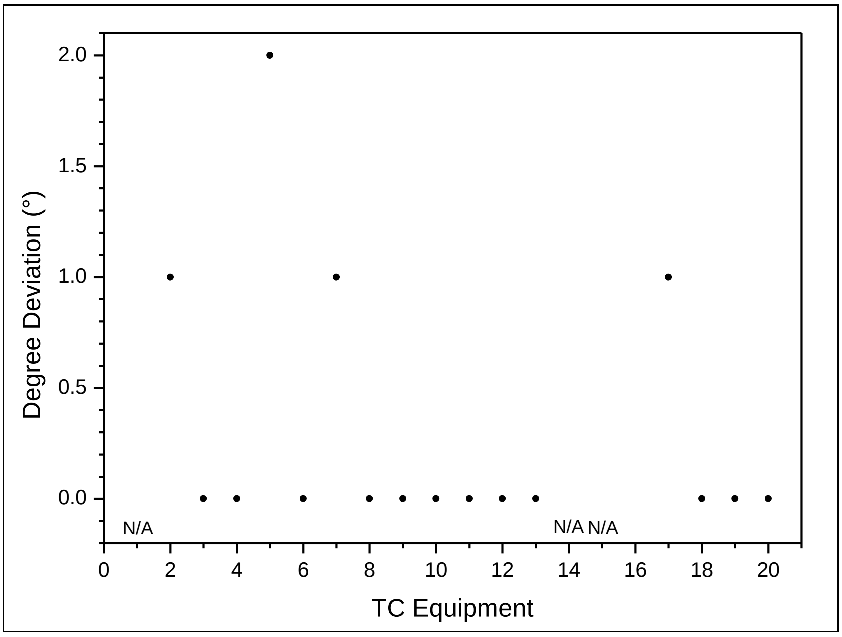

Figure 4 – Assessment of gantry tilt accuracy.

4.3 Random uncertainty in pixel value (noise), field uniformity and the accuracy of the CT number

According to Figure 5 all CT evaluated in random uncertainty of pixel value tests were approved, showing a good image for visualization of small structures.

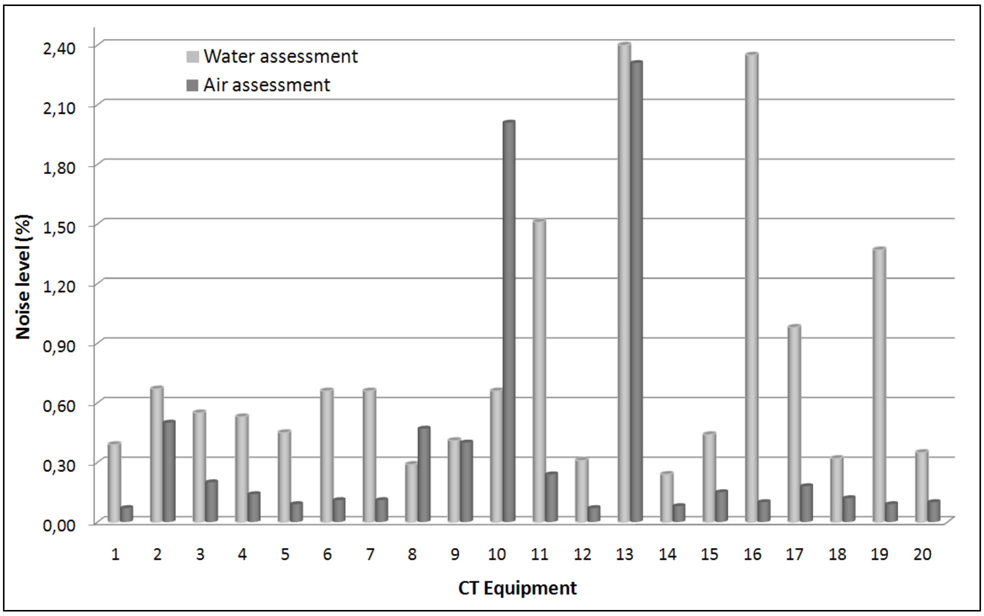

Figure 5 – Assessment random uncertainty in pixel value.

Figure 6 shows CT field uniformity results. All CT equipments evaluated the feature: images free of artifacts from the system; and an image of a uniform phantom should have uniform appearance without streaking and artifacts.

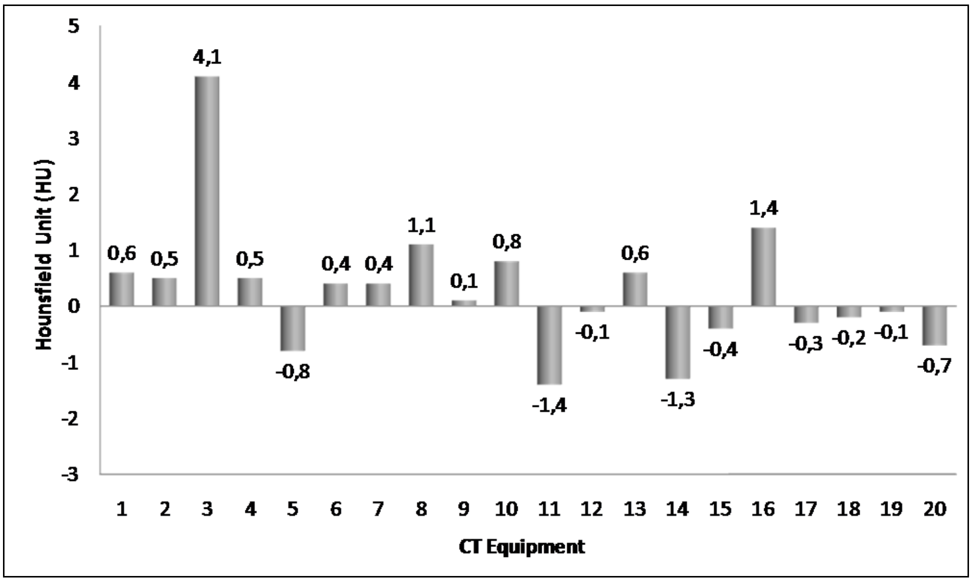

Figure 6 – Assessment of CT field uniformity.

Figure 7 shows the accuracy of the CT number results. It appears that all scanners had satisfactory results. Equipments 14 and 16 had the worst results, but were approved. In relation to air assessment, all equipments performed well.

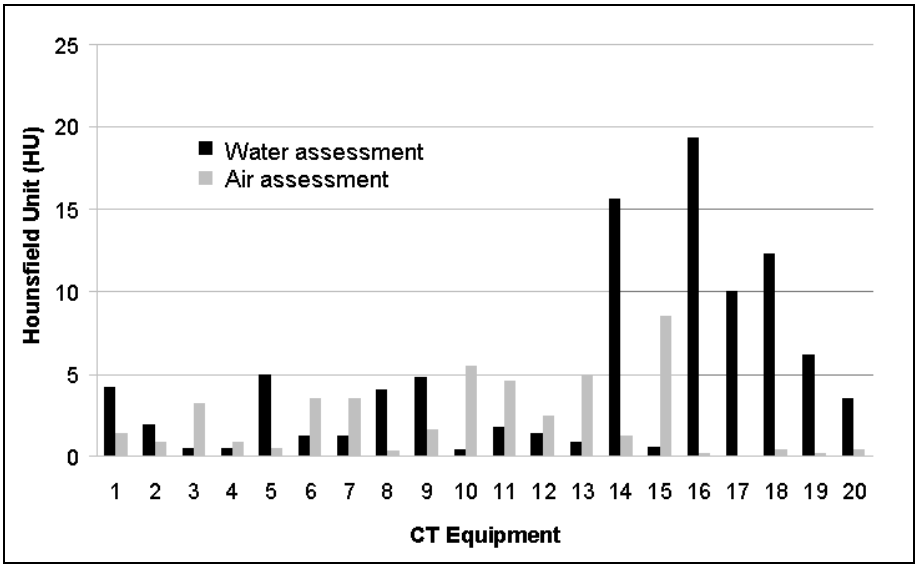

Figure 6 – Accuracy of the CT number in water and air assessment.

4.4 Spatial Resolution (High Contrast Resolution)

The values found in all CT scanners will be used for future comparison. No tomography showed a spatial resolution of less than 8 lp / mm. This shows that the equipment can detail objects of small size and high contrast, such as small kidney stones.

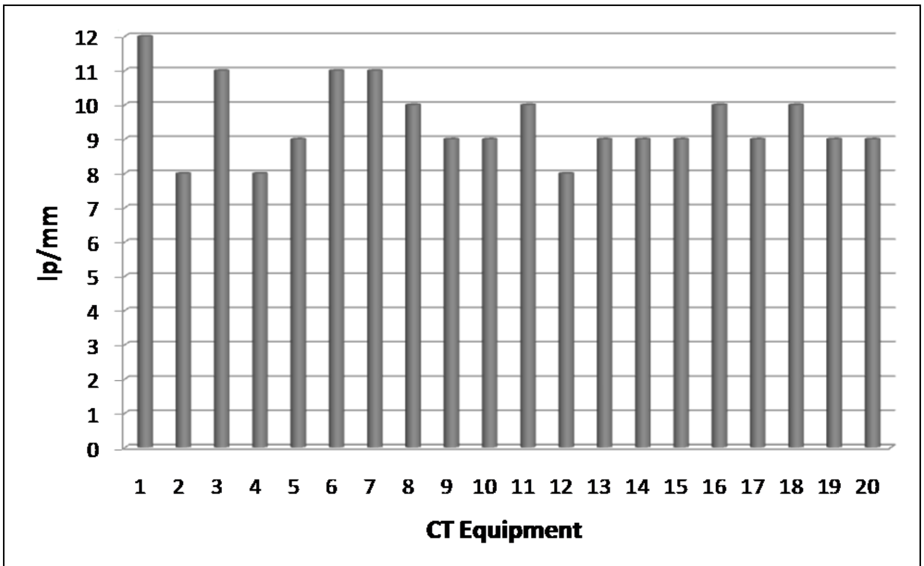

Figure 7 – Assessment of spatial resolution.

4.5 Contrast Resolution (Low Contrast Resolution)

According to Figure 8, four CT scanners did not perform well in this evaluation. The adequate contrast resolution ensures an optimal differentiation of similar regions on the gray scale, enabling better medical evaluation of structures to be analyzed and provides correct diagnosis.

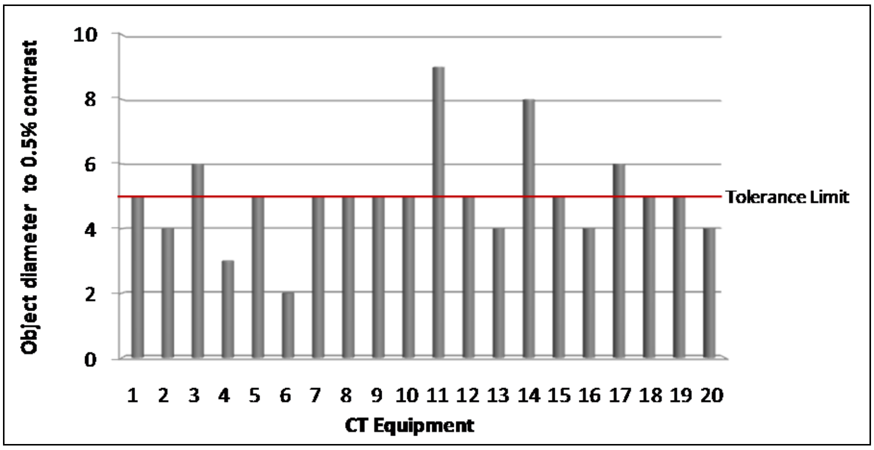

Figure 8 - Assessment of the spatial resolution of low contrast.

4.6 Multiple Scan Average Dose (MSAD)

All CT scanners evaluated in this test had values considered as compliant for each protocol type, according to figure 9. Some equipment also presented satisfactory results a lot under the limit of the expected MSAD. This indicates that all equipment go through a good quality control. The result is a decrease in MSAD without loss of image quality.

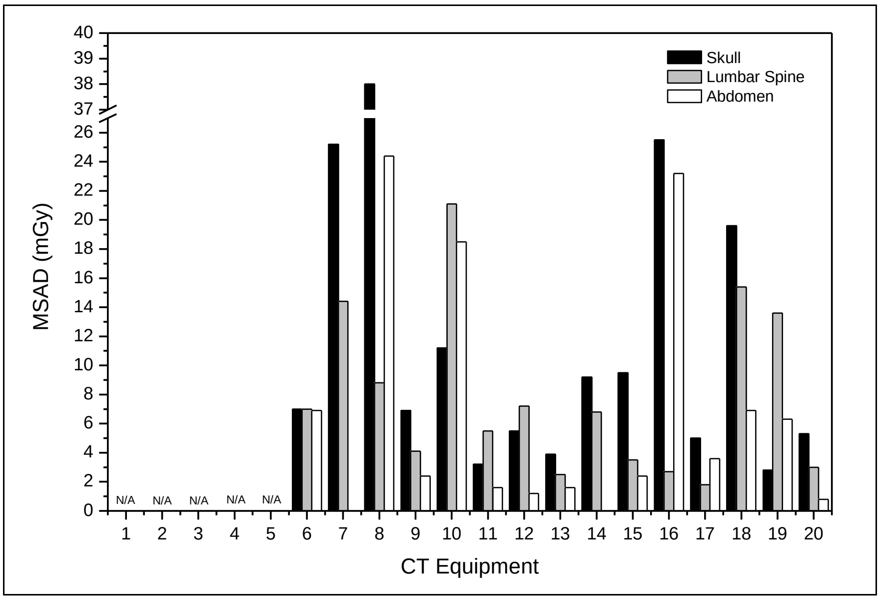

Figure 4 – Assessment of MSAD with protocol of skull.

5. CONCLUSIONS

From the analysis of tests, it was observed that the twenty-CT scanners showed a high rate of approval. Considering it was the first assessment of the quality control of these scanners, it is concluded that the equipment used in clinics and hospitals present a good image quality.

To assure the CT scanners will continue to respond satisfactorily, quality control should continue to be applied in such equipments.

REFERENCES

1. PINA *et al.* Controle de qualidade e dosimetria em equipamentos de tomografia computadorizada. Revista Radiologia Brasileira, São Paulo, p.171-177, mai./jun. 2009.
2. SOARES, Flávio Augusto Penna. Produção de raios X em ampolas radiográficas: Estudo do Tomógrafo Computadorizado do Hospital Regional de São José/SC. 2006. 102f. Tese (Doutorado em Física Experimental) – Universidade Federal de Santa Catarina, Florianópolis, 2006.
3. CARVALHO, Antônio Carlos Pires. História da Tomografia Computadorizada. 2007. Rev. Imagem, Rio de Janeiro, 6p, 2007.
4. CNES - Cadastro Nacional de Estabelecimentos de Saúde. Ministério da Saúde. Relatórios de Equipamentos. Tomógrafos Computadorizados em Minas Gerais. Disponível em: <http://cnes.datasus.gov.br/Mod_Ind_Equipamento.asp?VEstado=31> Acesso em: 30 mar. 2011.
5. BRASIL. Ministério da Saúde. Agência Nacional de Vigilância Sanitária. Radiodiagnóstico Médico: Segurança e Desempenho de Equipamentos. Brasília, 2005. 104p.
6. BRASIL. Ministério da Saúde. Secretaria Nacional de Vigilância Sanitária. Portaria nº 453 de 01 jun. 1998. Diretrizes Básicas de Proteção Radiológica em Radiodiagnóstico Médico e Odontológico.
7. THE PHANTOM LABORATORY. Manual: Catphan 500 and 600. Greenwich, NY. 2009. 37p.
8. T.S. Curry, J.E. Dowdey, and R.C. Murry, Christensen's Physics of Diagnostic Radiology, 4th ed. Lea & Febiger, PA, Malvern, 1990.
9. AAPM. Quality assurance for computed-tomography simulators and the computed tomography-simulation process: Report of the AAPM Radiation Therapy Committee Task Group No. 66. Medical Physics, Vol. 30, No. 10, October 2003